Geophysical Research Abstracts
Vol. 13, EGU2011-9891, 2011
EGU General Assembly 2011

The long-term seismic cycle at a subduction thrust in geodynamic numerical simulations compared to analogue gelatin models

Ylona van Dinther (1), Taras V. Gerya (1), Fabio Corbi (2), Francesca Funiciello (2), Luis A. Dalguer (1), and P. Martin Mai (3)

(1) Institute of Geophysics, ETH Zurich, Zurich, Switzerland (ylona.vandinther@tomo.ig.erdw.ethz.ch), (2) Department of Geology, Universita degli Studi 'Roma Tre', Roma, Italy, (3) Division of Physical Sciences & Engineering, KAUST, Thuwal, Saudi Arabia

The bulk of global seismic energy release occurs at subduction zones. However, specifically in these convergent settings, a lot of questions remain unanswered largely due to their inaccessibility and complex settings with a wide variety of materials and fluids. Moreover, while abundant data are available to help understand the short-term behavior of subduction-zone earthquakes, the long-term evolution of seismicity remains elusive. To arrive at a simplified yet realistic model setup to numerically investigate the long-term seismic cycle in this tectonic setting, we compare our computational geodynamic model to a recently developed analogue model. This comparison allows the benchmarking of both procedures, whereas the simplified setup helps to better understand the underlying physical and numerical aspects. Our main goal is to achieve and investigate a regular occurrence of seismic events in numerical models, as observed in analogue models. For this purpose we test the effect of different friction laws operating on the fault, including no weakening (i.e. static friction), instantaneous weakening, and rate-and-state friction.

Our fluid-dynamic, continuum numerical method involves a plane-strain conservative finite-difference scheme with marker-in-cell technique to solve the conservation of momentum, mass, and energy for a visco-elasto-plastic rheology (code I2ELVIS). Localizations of plastic strain develop at the thrust interface when the second invariant of the deviatoric stress tensor exceeds the Drucker-Prager yield criterion, leading to a correction to the pressure-dependent yield stress by decreasing a viscosity-like parameter. The simulated laboratory setup constitutes a triangular, visco-elastic crustal wedge on top of a straight subducting slab pushed against a backstop. The slab contains a prescribed seismogenic zone with either higher friction coefficients or velocity-weakening properties, located at the world averaged depth as determined by recent, worldwide observations. The adopted model parameters are directly taken from the laboratory experiments.

Preliminary numerical results show a crustal wedge moving landward during the interseismic-equivalent phase, where landward surface velocities decrease from the trench toward the backstop. In the meantime, the surface near the backstop is lifted upward, while stresses are mainly built up around the down-dip tip of the seismogenic zone. During the coseismic phase we observe a slipping event that nucleates at the bottom of the seismogenic zone, where stresses are highest, and propagates upward. Wedge velocities show a direction reversal, depicting a short, dominantly seaward motion during the event. Plastic deformation is completely localized along the bottom of the wedge, where stable, almost continuous sliding occurs in the areas around the seismogenic zone. So far we have simulated the entire seismic cycle in which characteristic features of GPS observations are captured by both numerical and analogue models. The observed periodicity will be quantified and investigated as a function of fault rheology and subduction velocity.